METHODS USED IN LOCATING AND PREVENTING RADIO INTERFERENCE FROM RURAL POWER LINES

Address before the St. Louis Section, Institute of Radio Engineers, by S. Lubin, Technical Standards Division, Rural Electrification Administration, Department of Agriculture, Delivered on September 30, 1942

I want to express my appreciation for being asked to appear before you this evening. Engineers are pretty clannish individuals, and it isn't often that the different branches of the engineering fraternity are able to get together for a discussion of common problems. Having started out as a radio engineer and worked nearly 10 years in that field, I am not a complete outsider here, but within the past 3 years I have been converted to the power engineering field, and I am here this evening in the capacity of a power engineer.

The problem of radio interference from power lines has usually been one with which the radio engineer hasn't bothered much. It has been something that he has had to live with, and he has either taken whatever corrective steps were possible in the radio installation or passed the buck right back to the power engineer. I hope, after this description of the problems that the power line designer and operator are faced with, that some of you will be stimulated into thinking of improved methods for the prevention and alleviation of radio interference.

There is a multitude of types of power lines in this country; there are high voltage transmission lines, low voltage transmission lines, urban and semi-urban distribution lines with various types of construction and rural lines which ramble over long distances through the countryside. Even for each of these types of lines there exist varied methods of construction, and each separate type presents a problem in itself insofar as radio interference is concerned. I intend to talk to you only on the specific problems that appear in connection with rural power distribution lines of the type constructed and operated by borrowers of the REA. I must admit that although I myself chose the title for this talk, it is, in a way, a misnomer.

When we use the term "method", we usually imply some sort of planned procedure--some knowledge of basic laws, formulas, equations, etc. That does not apply to radio interference problems. It is a rough and tumble fight with no holds barred and is based on about as much scientific knowledge as we had about radio phenomena in the old days. I don't need to tell any of you here that when you're working with radio there are times when you're about ready to conclude that science is the bunk. You've got all the wiring right, the calculations check on the nose and still the darned thing doesn't work. It's just the "innate cussedness of matter" that keeps the circuit from oscillating, and no scientist can talk you into believing that it's because you've made a mistake and forgotten to multiply by π.

Well, radio interference prevention and cure is still relatively undeveloped as far as method is concerned. If you work at it long enough, you may acquire a certain familiarity with the different types of interference, and after a time you can recognize some causes by the noise they make. You get pretty cocky about it. Then you get called out on a case, and after listening to the radio, decide that it's a faulty refrigerator motor. That's so easy that you just ask the lady of the house

to lead you to the refrigerator, and she takes you out on the back porch and shows you an old ice box dripping melted ice all over the place. That takes you down a few pegs. In fact, even if your mental equipment survives the shock, you're never the same again.

Before going into the so-called methods we use in REA to prevent and get rid of interference, I had perhaps better tell you a little about the REA.

The REA is a loan agency set up by the United States Government under the Department of Agriculture for the purpose of electrifying those rural areas of our country which are not now receiving central station service. Our program is carried out chiefly through loans to rural cooperative societies which are formed to build and operate distribution lines. These cooperatives employ a project engineer whose job it is to design and stake the distribution line, and a contractor who is charged with the actual construction work. The function of our engineering organization in St. Louis is to supervise the design, construction and operation of these lines, as well as to develop and maintain certain standards of construction and operation. This is obviously for the purpose of protecting the Government loan. The particular part of the REA with which I am associated is known as the Technical Standards Division. It is the function of this Division to develop the standards which are followed by the construction and operations engineers, as well as to develop new methods and equipment for increasing the efficiency and lowering the cost as well as improving the quality of electric service to the rural consumer. These activities constitute the more spectacular part of our job, but the major portion of our day to day work consists in providing consulting service to other engineering members of the REA staff and to the cooperatives who are our borrowers. It is clear that engineers engaged in routine construction and maintenance work can't spare the time needed to take care of special problems which arise outside this routine. For this purpose, the Technical Standards Division maintains a staff of engineers whose main job is to provide the answers to the "screwy" problems which are bound to arise on any electrical system.

REA line construction differs considerably from the usual type of construction employed in urban and even most rural distribution systems. The main difference is of course in the extreme length of our lines. These stretch cross country and do not necessarily follow along the traveled highways. In many cases they are built in places which even under the best weather conditions are inaccessible to maintenance trucks. We are therefore interested, whenever possible, in designing lines in such a way as to prevent trouble from arising rather than in applying correction after the trouble has appeared. As far as the differences in the line construction itself, our single phase lines, for example, are generally built without cross arms, using a design known as "vertical construction".

This consists of a phase wire attached to a pin insulator at the pole top and a neutral wire usually fastened to a side bracket on the pole about four feet below the phase wire. The neutral is multigrounded; that is, it is grounded at frequent intervals, perhaps every second or third pole, or in some cases, at every pole. Grounding is accomplished by running a wire from the neutral down the pole either to a grounding rod or to a coil of wire stapled to the butt of the pole. For better lightning protection, the same wire also extends above the neutral and runs to the top of the pole where it is clipped off flush with the pole top. The voltage between phase and neutral wire is generally 7200 volts.

Since the REA has made loans to more than 800 rural power distribution systems with slightly less than 400,000 miles of lines spread throughout the country and serving over a million rural consumers, it is natural that our small staff could not tackle each individual problem of each individual borrower. We attempt, therefore, to systematize and standardize the solutions to the various special problems which come up from time to time. Whenever possible, we work out methods which the system managers or members of their maintenance crews can learn to use in order to provide solutions without assistance from us. In this way, we have been able to reduce the number of special problems to be taken care of directly by our staff. We're not afraid, however, that we're doing ourselves out of a job, because no sooner has one problem been reduced to a systematic and simplified solution than at least two new ones crop up. In fact, in these days, with so many of our engineers leaving for service with the Army and Navy, we have been forced to side-track all but the most pressing problems.

However, to get back to the subject of radio interference, we have attempted to handle this problem in the same manner as the others. That is, to systematize the elimination and location of interference sources in such a manner that it becomes unnecessary to send our staff engineers across the country to investigate the reasons for the noise in Mr. Jones's radio on the back road ten miles from nowhere.

We have, to some extent, been successful in assisting our borrowers in assuming some of the burdens of the problem. We have been able to do this mainly by working in the direction of eliminating sources of interference by proper system design and by obtaining simplified equipment for interference location which can be used by the ordinary lineman. As far as design is concerned, we attempt to eliminate all known sources of interference at any point on the system. Probably the most prolific source of noise is the discharge of induced static charges between bodies at different potential levels. Loose hardware on a line pole can cause noise which will travel to great distances. Construction contractors and maintenance men are particularly cautioned to see that all hardware is kept tight in order to prevent arcing. Another cause of noise is improper spacing between metal parts on the pole and crossarms. Insulator pins, bolts and various metal hangers have static charges induced in them. Due to their separation by the crossarm and pole wood and the potential differences between the metal parts, electric stresses occur which may cause arcing or leakage currents resulting in high frequency interference. Our standard specifications have been designed to provide for appropriate spacing between metal parts on the pole in order to prevent such high frequency leakage. Where proper separation cannot be attained, an attempt is made to ground those metal parts which may be a source of noise. This solution must, however, be used with caution, and in each such case it is first determined how such grounding may affect the safety of maintenance personnel and the dependability and continuity of service.

Circuti breakers, transformers, lightning arrestors, cutouts and other line equipment of various manufacturers are carefully examined for possible sources of radio interference. Only after this is done are the devices approved for use on our lines.

Improper separation of the ground lead from pole hardware is frequently a cause of noise, and our designs have attempted to take cognizance of this factor. Wherever it appears that there may be a possibility of trouble due to the ground lead coming too close to, or rubbing against, the hardware, the design calls for a tight connection of the metal part to the ground lead. Sharp bends in leads from the phase

wire to transformers and breakers are avoided when the bend is close to hardware or ground leads to prevent noise from corona discharge. Loose ties of conductor to insulator and poor splicing of conductors are avoided, as these cause rasping noises familiar to any radio man who has ever hunted for a loose contact in a set.

The maintenance of proper insulation levels is an important factor in noise prevention. Conservative rating of line insulators and insistence on high flashover values and long leakage paths have been instrumental in avoiding trouble due to overstressed dielectric. Several makes and types of "radio interference proof" insulators are on the market. These insulators are usually coated with a semi-conducting film before glazing which tends to equalize the charge distribution over the insulator surface.

In spite of all our efforts to minimize the occurrence of interference, it does occur, and it then becomes necessary to locate the source and apply corrective measures. This is really the toughest of all the problems that we have to tackle. As I said before, it would be impossible for our own staff to handle each case which comes up throughout the 800 scattered systems in the country. We have therefore attempted to educate our system linemen in the location of at least the more common causes of interference and to provide them with simple apparatus for its detection. In order that the linemen may become acquainted with the types of noises and some of their causes, we have recommended that each system purchase a recording manufactured and distributed by one of the leading manufacturers of condensers and noise filters. This recording demonstrates various types of radio noises, both those produced by appliances and machines and those which originate on the power line itself. The use of this recording gives the maintenance man a lead on the place to look for the cause of the interference.

The main difficulty in noise source location has been in the availability of a cheap, portable and easily operated interference locator. Most of those which were on the market, when we began to look for something to recommend to our systems, were cumbersome and practically required a graduate radio engineer to operate them. They were, in addition, much too expensive for our non-profit cooperative systems to own. After many attempts, we were able to interest a well known manufacturer into putting on the market a low cost locator which was suitable for our borrowers. It took almost a year of designing and redesigning before we were able to get something that could be bought for less than $100.00. This locator is by no means perfect; in fact, it is more of an indicator than a locator, although it is equipped with both a collapsible pole antenna and a loop. Its directional sensitivity is fairly low. It is, however, portable, weighing only 20#, and mounted in a metal case with a convenient carrying handle at the top. An output meter is provided in order that visual indication as well as aural may be had. There is also provision for plugging in an antenna probe so that noise measurements can be made close to pole top insulators. Power is supplied by self-contained dry cells, or it may be operated from the 115 volt, 60 cycle power supply. As I said, it's not quite perfect, but it's the best available, and we take some pride in having fathered it.

Armed with this portable locator installed in the maintenance truck and able to compare noises with those on the recording, our systems have been able to handle nearly all the interference problems they encounter. As a result, the problems which are referred to our office here have dropped to about three cases in the past year.

An interesting case occurred just a short time ago which will serve to show that, at times, the complexity of the problem is due to the fact that more than one source of interference exists and that there is no substitute for perseverance and experience in tracking down noise sources.

An REA system was serving a Civil Air Patrol Base on one of the coasts. Shortly after the base put into operation its plane-to-ground radio communication service, it began to be troubled by interference. Our men went out and found that although the noise level at the base receiver was high, it was practically impossible to pick it up on the interference locator on the main line. After patrolling the line, the source of interference was finally traced to the half-mile tap constructed to serve the base. Inspection of the line showed that the ground leads on the pole were close enough to the hardware to cause radio interference. Correction of this fault removed a large portion of the interference, but there was still enough left to impair reception. It was then found that several of the line insulators were leaky, and all the insulators on the poles were replaced. After this change, an auto radio placed directly under the line could pick up no interference, yet the base radio continued to pick up some low level background noise. An inspection of the installation at the base showed that the antenna was considerably shorter than that required for efficient reception at the wave length used. The antenna was changed, and the signal-to-noise ratio increased to the point where interference was no longer picked up.

Other cases of interference occurring along the sea coast have been encountered due to salt deposits on the line insulators where the line was close to the shore. This is still one problem for which we have found no cure. The interference keeps up until rain comes along and washes away the salt deposits. The only remedy I can think of is an individual shower bath on each insulator. If any of you fellows have any ideas for a less expensive remedy, we'll be glad to hear about them.

Although I've talked only about those sources of interference which come from the rural distribution line alone, these are by no means the only noises that reach the rural consumer's radio. You are familiar, of course, with those forms of man-made static which originate in diathermy apparatus, DC generators, oil burners and vacuum cleaners. Then, too, there are the noises that originate right in the consumer's set and which are sometimes blamed on the power line. In addition, on REA systems we are sometimes blessed with another source. Most of our systems purchase power at wholesale from private utility systems. Some of these utility systems are themselves prolific sources of interference. In some cases power is purchased either from municipal plants or small local private systems which may not be in any too good repair. Faulty insulation, sparking of taps on step voltage regulators, and tree branches sweeping the lines on these systems create interference that is fed into the REA line. Where the trouble arises due to a fault on a large utility system, it is usually possible to arrange for elimination of the cause, but in the case of the small plant, it would require a complete rehabilitation of the distribution system to eliminate noise. In such cases it is sometimes possible to remedy the situation, at least to a bearable point, by insertion of chokes at the feed point into the REA line. When this fails, all the consumer can do is to grin and bear it.

I hope this talk hasn't been a disappointment to you. If you came expecting to hear about startling new developments in the way of getting rid of noise from that dentist's drill down on the corner, I'm sorry I couldn't give you the answer. The

only methods I know are the tried and true ones--either move, get rid of the dentist or get him to put a filter on his motor.

I want to emphasize that although we have done a great deal to eliminate power line interference, we haven't done all that can or should be done. We know some of the answers to the remaining problems, but there are still many answers that we have not found and would like to find. But, concentrating as we do mainly on problems of power line construction, maintenance and operation, we may not be in a position to find these answers. We hope that you radio engineers who are as much interested in this problem of radio interference as the power engineer is and who have both the experience and background in high frequency work which we lack, may be stimulated to tackle the problem of eliminating and preventing it. We will certainly be grateful for any suggestions that you can pass on to us.